HYGIENE OF REFLEX ACTION.*

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MAN is the only creature that can live anywhere in the world. He can make shift to get along on an island, a mountain, or a tree-top; in a cell, a desert, or a city. He will live an average lifetime on rice, blubber, or clay, and will submit to the most diverse conditions imposed by nature or himself. His pre-eminence in this respect is due to the differentiation of the functions of his nerve-centres, and the capacity they have acquired for storing up energy, which can be drawn upon to meet the vicissitudes of his changing environment. The more varied and thorough the training and experience of his nerve-centres, the better will he be equipped. In every community we see a natural elimination going on of individuals who imperfectly adapt themselves to the conditions of their lives, and it is with those subjects who imperfectly react, whether temporarily or habitually, to the stimuli which reach their nerve-centres, that the physician has to do.

Without stopping to describe the special mechanisms by which these adaptations are accomplished, and confining this discussion mainly to the functions of those cerebro-spinal centres immediately concerned in the associated reflex movements of the trunk and limbs, let us consider in a general way the effect upon the individual of their various states and reactions, especially as observed in orthopædic practice.

By countless filaments connected with receptive surfaces

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and spaces, showers of impressions are constantly pouring in upon the centres, some leading to no visible effect, yet not without effect, others going to set up changes which are directly reflected to the muscles and glands to spur them to action, or passed from cell to cell, and all ultimately modifying in some degree the function of the remotest cell in the body. By far the larger portion of these in-streaming stimuli are never consciously perceived, but help to form that substratum of unconscious life upon which the fabric of our being rests.

There is, therefore, a continuous, unperceived alimentation and training of the nerve-cells of the cerebro-spinal axis, from the absorption of incoming stimuli and, in many cases, their reflection along various paths; but, important as are the impressions received through the special sense-organs, particularly for consciousness, it is probable that the innumerable afferent impulses from skin, membrane, muscle, gland, and other tissues, responsive to changes in temperature and contact of the atmosphere and the blood, and changes in tension and position of the muscles and members, are equally fundamental and important.

A centre may have its activity re-enforced or interfered with by impulses from connected centres, and its function at any moment is the resultant of its own activity and all the re-enforcing and checking influences which reach it. Certain cells become specialized by inheritance or training, so that they store up the effect of impressions, giving out their impulses when properly stimulated. There is thus a selection of reflex arcs and paths in the evolution of the organism, so that, starting with but few and imperfect ones, many new ones are added according to its experience and necessities.

Reflex actions, as we observe them, are the products of the activity of many end-organs, fibres, and cells; the latter connected with neighboring cells of similar grade and distant cells of higher function, and through their influence reacting to an ever-changing environment. The co-ordination of complicated movements, to a small degree innate, is for the most part painfully wrought out by innumerable repetitions, failures, and modifications, until our reflexes become what they

are. A lady who has preserved the first little shoes of all her children tells me they exhibit evidence of the most varied use, one pair being worn at the toes, another at the heels, and others at the sides.

This acquirement of definite reflexes, *i.e.*, habits, is in the interest of an economy of force, and, once the needful associations are formed, volition is left free to initiate or control movements instead of laboriously executing them. "The digital struggle and facial contortion" of the youthful penman indicate the large number of nerve-cells necessarily involved in such an operation at first. Constant repetition and practice enable a much smaller group to do the work infinitely better, and at a fraction of the cost in protoplasmic wear. Talking, singing, playing on instruments, the use of tools, etc., and most of our oft-repeated actions, undergo similar improvement, to the economy of the organism and especially of the master-cells in the brain.

The reactions of the cord-centres will thus be seen to depend upon the nature and intensity of the stimuli received, so that we have a means of reaching and treating the nerve-centres by stimuli properly applied. When these are sufficiently varied, without being too numerous or too violent, the correlated peripheral and central areas readily act and react, each arc and group of arcs working out its experience and adjustment, until, in the same manner as a man's face reflects his character and experience, his hand or his back will acquire a form and expression largely dependent upon its neural life-history. Similarly, his carriage and attitude and the grace and dexterity of associate movements will depend upon previous training of the reflexes. We recognize a sailor or a case of Pott's disease at once from the gait, *i.e.*, from reflexes conditioned by special experiences.

The neural, and, to a great extent, the general vigor will depend upon the tonic action of large numbers of adequate adjustments and reactions well distributed over the different regions of the body. Unfortunately the environment supplied by our modern city life narrows the experiences of important regions of the body while it unduly quickens many purely cerebral processes, so that our wits are taxed more

than our muscles. Shoulders, chest, back, and loins, and with them the thoracic and abdominal viscera, suffer particularly from our restricted and feeble muscular experiences, which lowers the tone of the centres, as in Langley's experiment on the frog, where "the ordinary reflex action produced by the stimulation of one sciatic is diminished by section of the other sciatic" (Foster, p. 605). Many persons, in being shielded from the necessity of any sufficient variety or vigor of purposeful and useful reflexes, either never emerge from, or lapse into, a state of spinal torpor, where the logical tendency would be toward a purely vegetative existence and the shedding of the appendages, as has already happened in some of the crustacea. Such conditions of torpor from "starvation" of the spinal nerve-centres may exist with considerable cerebral activity of one kind or another—overstimulation of the brain is apt to depress the tone of the cord—which leads to the remark that in practice an uneven or vicious distribution of stimuli is more common than absolute excess or deficiency. How we do a thing is not less important than what we do and how much. One-sidedness is the disease that is killing us.

In general, the kind of education which the spine and brain get from manual proficiency is very solid and very wholesome, but this has been much curtailed in the artisan, professional, and leisure classes by the excessive monotony of impressions from the sudden development of the extreme division of labor and use of machinery which characterize our modern civilization. We are just beginning to realize that the experiences of skin, membrane, and muscle-regions are as important and more fundamental than auditory or visual impressions. One-sidedness tends to overuse of the active region, often culminating in strain and exhaustion of the centres, which produces a profound detrimental effect, not only upon their function but on tissue-metabolism. It would seem that for every organism there is a certain range of stimulation within which it reacts readily and makes easy adjustments and assimilations. When the stimuli become too intense, too constant, or too disorderly, symptoms of wear and overwork, a sort of "neural dyspepsia," show themselves in

the centres, and the nutrition of the body soon suffers, which in turn increases the protoplasmic distress in the centres and establishes a vicious circle, exceedingly difficult to break up. Disturbances of this kind beginning at one pole of the neural axis react upon the chain of connected ganglia, sweeping forward as a disturbing wave and exploding with peculiar violence at the terminal links. Thus among the numberless symptoms of brain-tire, debility and irritability of the genito-urinary and locomotor apparatus often occur, revealing the perturbed condition of the corresponding spinal centres. On the other hand, besides disturbed locomotor reflexes, states of profound mental depression, with a tendency to morbid religious notions, fear of suicide, and fear of insanity, at times amounting to melancholia, often result from imperfect sexual hygiene.

Health and mental vigor will be best secured by the exercise and co-ordination of large numbers of reflex arcs in widely separated parts of the body, and a rational distribution of neural reactions.

This view will present competitive athleticism, one form of one-sided use of the neuro-muscular apparatus, in a less favorable light as a health-promoter than has been claimed for it by some of its muscular advocates. Dissipation is the habitual excessive stimulation of nerve-centres, and will be detrimental according to the intensity, frequency, and duration of the molecular catastrophe and the grade of the cells involved. Thus medicinal, alcoholic, narcotic, alimentary, athletic, sexual, social, emotional, intellectual, and all other forms of intemperance are included from this point of view in one class as physiologically related.

The recent interesting experiments of Lombard show how delicately the knee-jerk reacts to the general condition of the body and the state of the centres. While they strengthen the view that the knee-jerk is not a true reflex act, its force seems to depend largely upon the state of the spinal centres, and one cannot help regarding its incessant variations as in some degree an index of the flushes of protoplasmic activity which there alternately glow and fade. These states will depend not only upon the stimuli directly received

from the periphery, but also upon those retarded impressions received from the brain.

Stimuli projected against a background in the centres appropriate to the production of painful sensations referred to a particular spot, as well as imperfect mechanical conditions, will interfere with the usual and normal reflexes of a part. Thus unstable footing from any cause, or a pain referred to a limb, will modify locomotor reflexes.

Practically, nothing is more certain than that we can educate the spinal reflexes. Persons who have been prevented from walking for many months on account of joint-disease or other cause have their cerebro-spinal habits very much modified, and, on the disappearance of the general or local trouble, it is found that locomotion is lost or imperfectly accomplished, and largely by direct exercise of the will. Analysis of such conditions, with recognition of the cerebral and spinal elements, is often necessary, preparatory to establishing a more ready and perfect reflex response to locomotor stimuli.

When the functions of joints or muscles have been interfered with by disease or design for considerable periods the habitual reflex arcs become rearranged; we say a patient has a trick or habit of walking. Instinct is not always a safe guide in such cases. There are many cripples and invalids who have not acquired the associated movements which would enable them to make the most of the limited motion in a damaged joint or the limited power in weakened muscles. These considerations will apply to many cases among the hemiplegics, paraplegics, and paretics, whether from cerebral or spinal lesions, in which the vitally important question for the patient will be how to get the best service in associated reflexes out of his imperfect cerebro-spinal apparatus. The fact that the muscles are not sufficiently used, or even the circumstance that the accustomed neural paths are not kept worn smooth, is not the whole explanation of the difficulty; the lack of proper afferent impulses from sufficient peripheral stimulation is in all probability a most important factor. Such cord and brain-centres, closely related to the member in question, as may still be intact, suffer from the lack of impinging stimuli and grow lethargic.

By a careful study and training of such capacity as exists, the physician will not only vastly improve the condition of these patients but give them the very best chance for increasing their powers by proper use. There are few cripples whose condition after the cessation of disease may not still be ameliorated with time and painstaking.

In the neuro-muscular degenerations following acute anterior polio-myelitis it is especially important to restore to the paretic extremities, so far as possible, the stimuli of locomotion and other normal associated movements without the inhibition of insecure footing and strained tissues. This should be the aim of mechanical treatment in such cases, and it is for the specific purpose of restoring to the damaged cord and muscles the cutaneous, muscular, and articular stimuli of locomotion that our apparatus are constructed. Even in mild cases a varus foot or wobbly ankle may produce such a sense of insecurity that the gait will be largely cerebral, consequently imperfect and exhausting, instead of mainly spinal and unconsciously performed; as in trying to walk on a slippery place or on rollers the postural reflexes of the knee, hip, and trunk—in fact, of the entire body—are rearranged by cerebral interference, and the joints held in special relations to afford a fixed point for the unsteady foot or to favor weakened muscles. Normal reflexes of locomotion are broken up and a wasteful and cumbersome set installed subject to constant cerebral interference in the efforts at balancing and progression, and additionally disturbed by the strain on weakened muscular and joint structures, which is rendered inevitable by the lack of balance between opposing groups. Thus the foot may be the key to the function and nutrition of the entire limb, and even to the health and carriage of the whole body.

Deformity having been overcome and the position of election given to the foot with exactness by mechanical support, and the direction and amount of motion precisely limited according to the indications, the sole is placed evenly upon the ground and the ankle held from lateral insecurity, so that the normal stimuli of pressure and motion are sent to the cord and reflected to the muscles, as well as the central

lesion will permit. This mechanical protection with muscular training enables the patient to acquire a better set of reflexes and promotes the nutrition of the part. The special vascular paresis of this condition is most successfully corrected by the stimuli of very hot air locally applied, by means of a box heated by alcohol or a gas-jet.

This is the theory of treatment of infantile paralysis. If many reflex arcs are severed this stimulating influence can be less perfectly produced, and its effect on the muscles whose motor-centres are absolutely and permanently destroyed must be largely lost. But the ultimate fate of such muscles is not doubtful, and the stimulating influence of correct relations and reactions of the locomotor apparatus will be felt in the posterior columns, and radiated by them to neighboring motor areas and to the brain; the latter effect is very often marked.

I.—A little girl, 6 years of age, brought to me in the fall of 1886, had been unable to stand or to walk since an attack of infantile paralysis three years previous. She had always been perfectly content to sit quietly on her mother's lap without inclination to talk or to join in the activity around her, but on being placed upon her feet and enabled to walk, at the end of two weeks, she apparently experienced an entire change of disposition; she became talkative, lively, and ambitious to join in the plays of the children, and her mother had difficulty in restraining her.

These conditions of treatment cannot be realized without the greatest care in the design and construction of apparatus and perfect exactness and precision in their application, with such progressive changes as may be necessitated by the altering indications. If a paralyzed knee or ankle is allowed to yield a little from faulty construction or application of the apparatus, inhibitory influences are at once excited which interfere with that symmetrical development of associated reflexes which has been mentioned. While it is not claimed that muscles which have absolutely disappeared can be restored, the plan of treatment above outlined is a rational attempt to make the best use of what are left, and it is astonishing how helpless many patients are, whose condition is really far from desperate, for lack of a little well-directed assistance

and training. The little girl just mentioned was brought to us two years before, and would then have come under treatment if the mother had not lost confidence by the favorable prognosis that the child would probably walk within two months.

II.—This little girl was severely paralyzed, but a boy of 9 years who came in March, 1886, and had never walked since his paralysis in November, 1885, was a case of only moderate severity. He had fair power in the right leg and could stand on it for a short time; the left leg was practically helpless; the knee was flexed 35 degrees, and abducted 20 degrees, and there was no power in the extensor muscles. There was a talipes equinus of 20 degrees at both ankles, as well as a tendency to valgus. These contractions were stretched by means of an apparatus, locked at the knee at the angle of choice and extending the entire length of the left leg, and an ankle-brace applied to the outside of the right foot with a screw-stop for progressively increasing ankle-flexion. These apparatus were so contrived as to be capable of progressive modification as the boy improved and to serve as supporting braces after the deformities were overcome.

The deformities were entirely rectified by the end of three weeks, with the exception of the knock-knee, which was so much diminished as to be no longer disabling. This patient has been walking freely ever since for considerable distances without other support than his braces, and his progress has been remarkable in other respects. The left (worst) leg gained, in the first year, 1½ inch at the top of the thigh, ½ inch each at the knee and calf in circumference, while the right leg gained 1½ inch, ⅝, and ½ inch respectively, the legs remaining equal in length. He was then able to walk with a free knee-joint and the lock was discarded, although there was no return of power in the quadriceps muscle. He could also walk very fairly without his braces, and it is, in my opinion, only a question of a moderate length of time before he will be able to discard mechanical support altogether.

The spasmodic condition of the neighboring muscles, resulting from the stimuli of the irritated tissues in progressive joint disease, presents a condition opposite to the one dis-

cussed. We cut off locomotor stimuli, in the acutest cases, by putting the patient to bed for a month or six weeks, and eliminate, so far as possible, by counter-extension the specially irritating and damaging stimuli occasioned by the rubbing and pressing of the inflamed surfaces. When the recession of the inflammatory action is fully inaugurated, we allow locomotion, with the weight borne on the perineal strap of the counter-extension splint, which takes the pressure from the joint and does not permit the foot to touch the ground, using crutches also if necessary. In the recovering stages it is desirable to permit a certain amount of stimulation, in order to promote nutrition, before the joint can safely bear pressure ; we therefore give the joint motion, the amount of which is regulated by proper stops on a jointed apparatus, which still suspends the leg and carries the weight on a perineal strap. In this way the amount and kind of reflex stimulation which the leg receives is carefully regulated according to the indications. The withdrawal of stimulation causes muscular weakness and wasting, which is favorable to the joint in the active stages of disease, but the muscles improve as the joint recovers and the stimuli are readmitted. It is thus seen that bracing a paralyzed leg and a diseased one have entirely different objects and results.

Variously disturbed and faulty reflexes are a prominent and sometimes the paramount factor in many cases of so-called " chronic sprains," neuroses of the joints, neurasthenic hysteria, sluggish and irritable viscera, imperfect general nutrition with nervous symptoms and backache, often distinguished by the bedridden or partly bedridden condition. This comprises a large and somewhat heterogeneous class of invalids, many of whom are exceedingly helpless and very great sufferers, whose condition is the logical, we may say the inevitable, result of faulty training of the reflexes, in themselves as well as in their ancestors. Their nervous system, and perhaps general nutrition, suffering according to circumstances and temperament from the strain or relaxation of imperfect adjustments, affords favorable conditions for the formation of local disturbances of reflex action from causes sometimes so slight as to escape observation. The neuro-

muscular machinery is vulnerable, and, given the proper soil, the abundant and varied crop of neural disorders easily germinates. Take a case of "chronic sprain." The patient presents himself to the physician usually with pain and tenderness in the affected part, often with wasting, rarely with heat or swelling, though a subjective sensation of burning and the puffiness of relaxed tissues are not uncommon. Disability of the most varied character and imperfect co-ordination of the neighboring muscular reflexes are among the most common symptoms, and the most characteristic one is the visible though often unconscious accommodation of the reflexes of the entire body to the condition of the disabled member. This is equally true of allied neuroses, and it is usually more distinct and more widely distributed than the secondary reflex adjustments in joint-disease, and somewhat different in character, possibly due to greater prominence of the cerebral element. If the patient have a lame ankle he is, so to speak, "ankle all over;" if it be a young woman with a backache, she presents every evidence in her conscious and unconscious life of the paramount influence of that region of the body. If we may speak of "care" as referring to attitude and movements in joint diseases, we may possibly characterize as "apprehension" the phenomena referred to in these functional troubles. The "care" of a diseased joint is most distinctly noticed in distant reflexes when the joint is hurt or threatened with violence. Pain, especially in the earlier stages of joint disease, is rather paroxysmal in character and often absent; the patient frequently forgets his trouble and hurts his joint by too spontaneous movement. In a neurotic joint affection, pain, while more constant, is not invariably a prominent feature, but, no matter what the distractions of the patient, the remotest muscular reflexes of the body are in a would-be-protective state of apprehension in a typical case. This influence can often be distinctly perceived in the expression of the face and the tone of the voice as well as in the peculiar mental attitude of the patient; the perceptions, emotions, and intellect will frequently revolve around a knee or a back for a centre as plainly as the muscular reflexes. So-called "chronic sprains," as I have seen them, usually re-

solve themselves into disturbances of the associated reflexes about the joint in question, whose starting-point has often been a real sprain or strain, but which had long before recovered, leaving disordered neuro-muscular action in its wake; these in turn interfere with the nutrition of the part and keep up the pain, which originally may have represented a slight organic lesion.

III.—A gentleman, aged 38, came in May, 1883, to have a brace applied to his right ankle, which he had sprained three months previously. There was pain and disability from the time of the accident. He did not use the foot for four weeks, and after that walked lame and only for short distances. The examination showed pain and tenderness about the ankle, especially the outside, with limited motion and irregular, spasmodic action of the muscles. Considerable motion at the ankle was brought out by finessing, much to the patient's surprise, as he could scarcely move it at all when told to do so. The diagnosis of disturbed reflexes about the ankle-joint without present organic lesion was made, and education of the reflexes by passive and active movements advised and begun. On the third day motion was nearly normal, with scarcely any pain, and the patient stated he had not felt so well since the accident. Three days later the patient was discharged cured, with normal locomotion, the movements of the ankle being perfectly natural and under control. Eight months after he was reported as continuing perfectly well.

IV.—A lady, about 50 years old, came to me in June, 1884. She had slipped on a piece of orange peel and turned the left ankle two years previously. This accident was followed by pain, swelling, and disability. She walked for the first time, six weeks after the accident, and then for a long time, from sickness in the family, she was obliged to be constantly on her feet and suffered from overexertion, anxiety, and broken rest. She asserted that pain, heat, swelling, and lameness had continued up to the time of examination, and had been worse during the previous six or eight weeks. The symptoms had been so severe that for a week before coming she had used crutches. The patient was a delicate woman,

who had been worn out by mental strain and overexertion. She had had milk-leg on both sides several times, and varicose veins were present. The examination showed no swelling. She was able to relax the ankle and permit it to move naturally in all directions, and also to execute these movements voluntarily. She said she had never tried to move the ankle before, and did not know that she could. It was explained to the patient that the ankle was suffering from disuse and imperfect hygiene. The crutches were at once discarded, and physical, educational, and developmental treatment begun. In a week the patient stated that she did not know she had an ankle, and was able to lie on the left side, which she had not done before. She remained for several weeks for general tonic treatment, and has since been seen socially from time to time, and reported that her ankle had remained well and that only occasionally, after overexertion, was she reminded of the accident.

V.—While passing through Fall River in July, 1884, I was called to see a large, athletic young man, 17 years old, whose left knee had given out while tramping through Switzerland six months previously. He afterward limped when he tried to use it, and thought that it swelled. He had been better and worse by turns, but the knee had never ceased to trouble him, and for ten weeks he had walked on a crutch and a cane, bearing very little weight on the affected limb. Naturally energetic, he felt his condition very much, and chafed under the awkward work he made in hobbling around, and was exceedingly anxious to be relieved. The left thigh measured 1 inch less at the top, $1\frac{1}{4}$ inch less above the knee, $\frac{3}{4}$ of an inch less at the calf, and $\frac{1}{2}$ inch less over the knee, although he believed it to be swelled. Mobility was good, and it was perfectly evident that the limb was suffering from nothing except disuse. After going through a few passive and active movements of the leg in various directions, I got him to stand up with his feet flat on the floor, and made him bear his weight on both limbs. Inside of five minutes I had him walking around the table without assistance, and, to follow up the impression, I took him a short turn in the street and up the front steps of the house. At the end of fifteen

minutes he walked without a limp, and I took my leave of the bewildered family. This young man never had any trouble afterward, and played on the Harvard team in the intercollegiate football match last Thanksgiving.

VI.—A married lady, 44 years of age, came in May, 1884. She had suffered a great deal with her left knee for 30 years. While at boarding-school at the age of 14 her knee began to hurt her at times, especially on stepping up, but she did not remember to have injured it. She afterward met with a number of rather trivial accidents which had laid her up for months at a time and obliged her to use crutches; the knee also troubled her sometimes without known cause, so that it was often treated locally. Two years before coming she fell and struck her knee, and since then had used crutches constantly and kept the knee bandaged. Aching had been frequent and, since the last accident, located on the inner aspect of the knee below the patella. The patient held her knee in continuous complete extension, as had been her habit when it troubled her (I have noticed this peculiarity, impossible to the sufferer from synovitis, in several cases). Her right knee measured 1¼ inch, and the right calf 1¾ inch less than the left. She was of nervous temperament, but of fair physique and general health, and not morbid. Examination showed no organic change in the joint, except that incident to prolonged disuse. The knee-motion was of considerable extent and good quality, but voluntary control of the muscles moving the knee was deficient. She could hold the knee out when sitting, but not extend it from the flexed position. The diagnosis was atrophy of the limb and probable dryness of the knee-joint from disuse and disturbed reflexes. Graduated passive movements at the knee by special apparatus actuated by steam-power were given for half an hour daily, and gradually increased in extent and duration. She was also drilled in placing the foot squarely on the floor, in bending the knee, and in gradually increasing the amount of weight borne upon the limb as she walked with the crutches. This was followed in a few days by some increase of pain and considerable puffiness about the knee, though the exercises themselves were not painful. Nine days after

beginning the treatment she was able to extend the leg from the flexed position; three days later she laid the crutches aside, walking readily, though with a slight limp. In a month after coming she was able to bend her knee and to walk considerable distances without crutches, and the pain had greatly diminished. She gained markedly in flesh and in spirits, and lost the drawn and anxious expression she had had. In five weeks from coming the affected knee had gained one inch in circumference and the calf 1¾ inch, and the patient returned to her home. She has since been frequently reported by members of her family as enjoying perfect health and locomotion.

VII.—A bright, active, intense woman, 27 years of age, came in May, 1885. She had fallen, striking the lower part of her left knee, seven months before. It pained her only moderately, and she went on teaching as usual, not walking much, until two weeks afterward the knee became red and swollen, and there was a pricking pain. She was put to bed and kept there four months, blisters and iodine being applied to the knee. During this time the knee was kept stiffly extended, and when she got up it was put in plaster for three weeks, and she walked on crutches, with a high sole on the right foot. She came on crutches, and had not borne any weight on the left leg since she went to bed. She had had burning, itching, and aching sensations in the knee, aggravated by motion, but no sharp pains. The patient's health had always been good, and she had had no previous sickness. She had felt the effect of her knee-trouble severely, but did not think she had lost much flesh; a few days after coming she weighed 97¾ pounds. Examination showed that the limb was held in complete extension by contraction of the quadriceps. There was about 10 degrees of voluntary and restrained passive motion, which was not very painful, though the patient was apprehensive; when her attention was distracted the motion was somewhat greater. The thigh and leg rotated outward when the patient was lying on her back; the muscles and even the subcutaneous tissues were very much atrophied, and the skin very thin, having the appearance of being drawn over the bones like parchment. The

measurements were as follows: Above the knee, right, 13⅞ inches; left, 12; knee, right, 13¼; left, 12½; calf, right, 12; left, 10¼; there was no evidence of any inflammatory trouble in or about the joint, nor of any organic lesion anywhere. Diagnosis of restraint and abnormal reflexes following slight injury was made and the condition explained to the patient, who was then able, with a little preliminary training, to walk alone without crutches in a few moments, with only moderate discomfort and very little limping. Systematic passive movements and training of the reflexes were begun at once. There was some puffiness and muscular soreness during the first few days, but at the end of two weeks there was very great improvement in the condition and nutrition of the leg, which had already gained an inch in the calf and lower thigh measurements. Five days later she discarded her crutches entirely, and there was a gain of 1½ and 1¼ inch at the lower part of the thigh and the calf respectively, over the first measurements. The patient left in about six weeks, with perfect motion and good control over the knee, though it had not yet attained the strength of the right leg. Her general health was perfectly restored, and she had gained, in five weeks, 7¾ pounds.

With some care on the part of the patient the knee continued to improve during the summer, and in April, 1886, she called to demonstrate its entire restoration, the legs being then equal in size and function.

VIII.—A little girl, 9 years old, was brought in the fall of 1882, walking on crutches, which she had used for a year, during which time she had suffered from pain in the right hip with extreme flexion at the hip and knee. All efforts to straighten the leg caused such excruciating pain that they had to be abandoned. The muscles relaxed under ether, but on recovering from the anæsthetic they became as rigid as before. Her family physician had recognized the neurotic nature of the case, but all of his efforts at procuring relief had been completely baffled. She was an excessively intense, self-conscious child; her general health was fair, and she was very happy in running around on her crutches and joining in the plays of the children. Five months of training, which

was not directed to the hip, as she was already hyper-conscious of that part, were followed by a complete cure, and she went home without pain and walking perfectly. This little girl had pain at the hip at long intervals for a considerable time, but she never had any recurrence of the functional trouble in that location.

She was brought to me three years afterward as a bedridden invalid suffering from backache and extreme mental depression. After a long and varied experience, she was taken home in an essentially bedridden condition and has never walked since. There is no question of any organic disease, she is simply floored by her chaotic reflexes.

IX.—A lady about 40 years of age, the wife of a physician, consulted me in September, 1885, about her left shoulder; she had wrenched it three months before while trying to save herself from falling on the stairs. She did fall, and bruised herself in several places, but not on the shoulder. Her arm was afterward stiff and painful, and she found it powerless at the shoulder and elbow; she carried her arm in a sling, and it had been treated electrically. At the time of the examination there was pain in the elbow when she raised the arm; she could not raise the hand to the face nor abduct the arm more than 45 degrees from the side. When passive movements were made the muscles about the shoulder resisted, and motion was not free. Diagnosis—of restraint and disturbed reflexes. Training of the reflexes by systematic movements was followed by marked improvement in mobility and usefulness of the arm, but after being treated for a week the patient was obliged to leave and went home with the arm still very much disabled. It remained in about the same condition until the death of her husband, which occurred unexpectedly a few weeks later. The shock was so great that she became entirely unconscious of her arm, and from that time it has been perfectly normal in every respect, as she was able to prove to me at her next visit.

Cases similar to the above are of very frequent occurrence in our practice. I recently saw a gentleman who had walked with the toes and inner border of the foot elevated for nine years, without organic lesion. Some time ago a lady reported

who had walked many years with her toes voluntarily digging into the ground at every step. Only a few weeks ago I saw a lady in whom a rather severe injury to one finger had been followed by disturbed reflexes of the arm. I have under my observation at the present time a young lady in whom weakness of the knee from relaxed ligaments caused such severe pains across the back and down the thighs, and so much disability, that there seemed to be hesitation on the part of the patient and of her father, who was a physician, in accepting the diagnosis of disturbed neurility from knee-strain alone. Avoidance of locomotion for a few weeks caused an entire disappearance of pain in the back. Such instances might be indefinitely multiplied. I see more cases of functional joint troubles than of joint diseases ; they are exceedingly common in this country, and the importance of carefully differentiating between the two conditions can hardly be exaggerated, as many of these functional troubles will be indefinitely prolonged, with great distress and harm to the patient, unless recognized and properly treated.

I have already referred to the fact that there is a wide range of disturbance even in those cases where local trouble predominates. Not a few, beginning with a local disorder, degenerate into a condition of general invalidism, with scarcely any normally adjusted reflexes, as in the case of the child bedridden at thirteen. This is more apt to happen when the main disturbance is in the trunk, back, or viscera—of course, the primary and essential trouble lies in imperfect adjustments of the higher cerebral centres in a very large number of cases, but that element only enters incidentally into this discussion.

X.—A little girl, 12 years old, an only child, was brought in May, 1884; she had always been delicate and the object of great solicitude on the part of her parents. She had suffered at various times from chills and sick stomach ; the last time in November, 1883, when these symptoms, with pain in the back and jaundice, followed a fall. She had been allowed to walk but very little afterward, and, as she continued to complain of her back, caries of the spine was suspected and an apparatus applied, which she still wore. She was pale and

thin, with an expression indicating solicitude, and was carried from the door to the office in a chair. It was perfectly evident that the entire family, including the sufferer, were intently engaged in watching for the development of expected symptoms. Examination of the spine showed it to be quite normal, with the exception of a slight bending occasioned by the shortness of one leg from asymmetrical growth of the extremities. Diagnosis of reflex debility, the effect of "too much mother," was confirmed by the rapid improvement which followed separation from the parents. Gentle exercises calculated to give tone to the cord and develop the associated reflexes of the trunk and limbs were given, and, the burden of constant repression and restriction being removed, it was a pleasure to see the pale, sad child taking her first taste of natural childhood. On the ninth day she walked two miles; on the tenth she walked upstairs for the first time, an effort which the spinal neurasthenic instinctively avoids. In three weeks from coming she was riding on horseback, and at the end of two months she returned home in perfect health. I am confident she would have suffered a relapse had we not undertaken the education of the parents, who had become completely demoralized by the abnormal relation to an only child, and who were trained with difficulty not to watch nor repress her. She returned for inspection in five months, natural and well in every respect, and having gained considerably in weight and height.

XI.—In May, 1886, a gentleman, 28 years old, who had always been rather delicate and had broken down at college five years before, came with a variety of complaints, of which backache and general debility were very prominent. He had not been able to do any work since leaving college, and had been growing steadily worse, until he was unable to sit up for his meals, and even talking made his back ache unbearably. Pain and apprehension, with introspection and mental and physical demoralization, made him a helpless wreck. The attempt was made to tone up the centres and restore the equipoise of the various functions by properly directed exercises. He proved a difficult case, but the attempt was so successful that he was able to leave for home comparatively

restored at the end of two months. I continued to advise him by letter from time to time after the discontinuance of the treatment, as is my invariable custom in such cases. The following fall he took a position as civil engineer with a field-party, which he has held creditably ever since, and when I saw him a few months ago he was a perfectly healthy young man.

XII.—A case similar as to the general condition, approaching the bedridden state, with excruciating pain in the back, great prostration, disinclination to exertion, and abnormal reflexes of the back muscles, was that of a young lady who came to me in February, 1886. The pain was so great—"as if her back would break in two," she expressed it—that it had led to the diagnosis of Pott's disease, and the application of a plaster jacket, which she was still wearing. In spite of the protest of the patient, for her reflexes had accommodated themselves to the rigid casing, the jacket was at once removed and the usual means for the development of neuro-muscular tone were employed. This case returned home at the end of two months in fair health and much relieved, but I have recently heard that she has relapsed.

XIII.—The next case was that of a lady, aged 34, who had been confined to the bed and a wheel-chair for seventeen years. She stated soon after coming, December, 1884, that exactly seventeen years before she had gone to church for the last time and attended five services. Spinal pain and weakness had been prominent symptoms throughout the case, and had resulted in a readjustment of the reflexes to the abnormally restricted condition. That this patient was walking within a few days and improved steadily in all respects was largely due to her own intelligent and hearty co-operation, once the condition was explained to her. For some weeks her main difficulty was in accustoming the soles to bear the pressure of use, for the feet had lost their form and character, and required to be reshaped. She went home at the end of four months, walking freely and in fair health. A month after she reported in fine condition, having gained twenty-five pounds in four months and a half. While not robust she leads a tolerably active life, visiting, shopping,

and attending to her domestic and social duties at her pleasure.

It is not necessary to prolong this enumeration of type-cases, where, from causes depending upon local conditions and upon states of the centres, the associated reflexes of the trunk and limbs, or of special areas, have become too keen, too sluggish, or too disorderly. The object of these outlines is to indicate that such detrimental conditions do exist in various localities, either alone or associated with organic or functional troubles, and that they are susceptible of analysis and rational treatment. Sometimes the consideration of faulty reflexes will not be important, in view of more urgent indications, but there are cases of serious local or general disturbance where the best results have been obtained by progressive, systematic training and development of associated muscular movements. By thus feeding in appropriate stimuli, we can fill up gaps and reclaim barrens in the centres, balancing and distributing nerve-force as may be desired. The steps must often be so gradual as to commit the centres to a certain line of action, stimulate consciousness of power, and promote nutrition, without exciting the inhibition of undue fatigue, pain, apprehension, or resistance, but in certain cases very much may be accomplished by sudden and profound impressions. The training will often be directed to regions remote from the part affected; for instance, a functional spasm in the lower extremity may be favorably affected by the exercise of the trunk and arms as a physiological diversion. The effect of local treatment in exaggerating the attention already fixed upon the affected part should be carefully considered.

We are frequently obliged to draw up a physiological balance-sheet, and, if necessary, place the system in the hands of a receiver, going over the assets and liabilities, finding where the former can be increased and the latter diminished, where idle capital can be made to yield interest, and wasteful extravagance checked. These patients have the right to expect something more than the prescription of drugs, diet, braces, or exercise. Quantitative analysis of the various activities of the organism will be needed, and a complete system of physical economies adopted, which shall recognize and regulate, so

far as may be desirable, all the functions and all the conditions of life. Change of moral atmosphere, separation from the family, the acquisition of definite aims and purposes, the control of emotional excess, the introduction of order and system into daily habits, are examples of what is meant.

Much of this will best be done indirectly by the modifying influence of neuro-muscular training on the organism and its higher centres. We wish to practise economy in the organism, not that we may spend less, but more in the long run. Analysis should reveal weak points in order to strengthen them and make the organism more efficient.

In concluding, I will mention some of the means which we have found useful in promoting reflex hygiene: Daily rest, lying down at a stated hour, with complete relaxation of mind and body.

Systematic heating of the legs from above the knees by the hot-air box, kept at a temperature of about 130–140° F.

Drill in the "standing frame," with knees or hips, or both, supported, thus training the centres without the disturbing influence of balancing the body, and enabling the physician to throw more or fewer muscle-groups into active use while giving all the stimulus of standing.

Drill in locomotion, free or between parallel bars.

Localized active and passive movements by hand and by means of special apparatus, susceptible of accurate adjustment of the resistance and amount of motion, among the most useful of which for the purpose considered are:

Passive alternate, right and left flexion of the trunk by means of steam-power apparatus, patient lying; 46 complete movements a minute; 2,760 an hour.

Active flexion and extension of trunk through lumbar region, patient lying; the upper or lower half of the body fixed as desired.

Passive (steam-power) flexion and extension at the knees, patient seated. This apparatus gives 25 movements of flexion and extension a minute; 1,500 an hour.

Passive (steam-power) flexion and extension at hips and knees, patient partly reclining; 23 complete movements a minute, or about 1,400 an hour.

Active extension at the hips and knees, patient partly reclining; and flexion and extension at ankle, both against graduated resistance.

Weight and pulley for arm-movements.

Artificial respiration by means of an apparatus known as the "respirator" (steam-power), which produces full inspiration and expiration, by drawing the arms of the patient strongly upward, the chest being at the same time arched back; the patient is reclining and passive, except as to grasping the handles of the apparatus. This machine has rendered us yeoman service in regulating reflexes and distributing nerve-energy, besides which, it develops the chest, oxygenates the blood, equalizes the circulation—warming the extremities—and acts as a general tonic to the system. We use two apparatus, one giving 13 and the other 16 respirations a minute.

The exercise-room is provided with couches, and all patients are required to rest before and after each movement.

What I wish to emphasize as the central idea of this paper is the development and use of associated reflexes as a practical means of modifying nerve-centre function. The spinal and cerebral factors are to be recognized and differentiated, in order to send re-enforcing or inhibiting impressions into appropriate areas, by applying or removing particular stimuli, and thus to effect an advantageous redistribution of their energy.